Phys 131 2016

Lecture 14

Note quiz from Weds.

Mon Warm Up 6

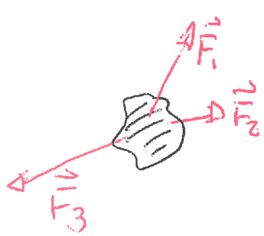
Tues: Discussion/quiz

~~Stopper Ex.~~

Ch 6 Conc. Q 10, 16

Ch 6 Probs. 24, 26, 30, 44

Newton's 2nd Law connects the forces on an object (describing interactions) with the acceleration (describing motion).



$$\vec{F}_{net} = \sum \vec{F}_i$$

and

$$\vec{F}_{net} = m\vec{a} \Rightarrow \begin{aligned} \sum F_x &= ma_x \\ \sum F_y &= ma_y \end{aligned}$$

Quiz 1 90% $\}$ 80% – 95%

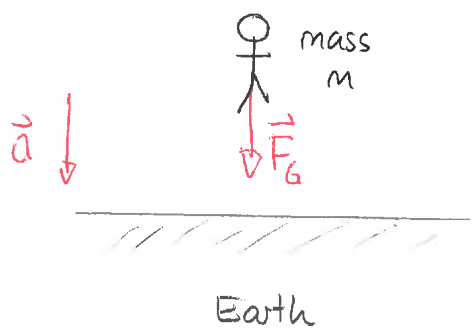
Quiz 2 50% → 90% $\}$ 90%

Demo: Spring scale

The remaining task in Newtonian/classical mechanics is to specify rules for various forces. These rules are based on experimental observations of the behavior of objects when interacting with other objects in various ways

Gravitational force (near surface of a large object)

There exists a general rule for gravitational forces exerted by any object on any other object. This takes a simplified form when an object is near to the surface of a much larger object. Consider an object in free fall near Earth's surface. Then



Newton's second law

$$\vec{F}_{net} = m\vec{a}$$

$$\Downarrow$$

$$\vec{F}_G = m\vec{a}$$

$F_G = ma$ ← magnitude of acceleration

Observation

acceleration is straight down with magnitude g

$$\Downarrow$$

$$F_G = mg$$

This force is always present regardless of the motion of the object. Thus

> Earth always exerts a gravitational force on any object near to its surface. The gravitational force, $\vec{F}_G$:
>
> 1) points to the center of Earth
> 2) has magnitude $F_G = mg$
>
> where m is the mass of the object and g the positive magnitude of acceleration due to Earth's gravity.

<u>Note</u>:

1) F_G is different to "g"
2) gravitational force depends on mass, acceleration in free fall does not
3) gravitational force is independent of object's motion

Normal forces

Normal forces arise from interactions between microscopic charged particles in the surfaces (which are in contact with each other). There is no general rule for this force - it must be inferred from the situation. So

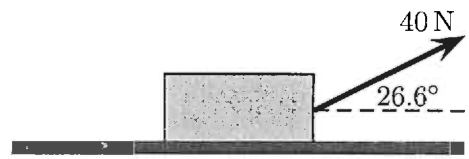
> When the surfaces of two objects are in contact, there will exist a normal force. This force has:
>
> 1) direction perpendicular to the surfaces
>
> 2) a magnitude which adjusts depending on the situation

Quiz 3 40% → 70% ⸨ 30% - 90%

Quiz 4

36 Dynamics of a single object

A 5.0 kg box can move along a frictionless horizontal surface. A person exerts a force at the illustrated angle. The aim of this exercise is to use Newton's laws to determine the acceleration of the box and the normal force exerted by the surface (provided that the box stays on the surface).



The *entire collection* of these steps is called "applying Newton's laws of mechanics to determine the acceleration of the block."

a) Draw a free body diagram for the block.

b) Write Newton's Second Law in its component form, i.e. write

$$F_{\text{net }x} = \Sigma F_x = \cdots \tag{3}$$
$$F_{\text{net }y} = \Sigma F_y = \cdots \tag{4}$$

Insert as much information as possible about the components of acceleration at this stage. You will return to these equations shortly; they will generate the algebra that eventually gives you the acceleration and the normal force.

c) Determine the magnitude of the gravitational force. Let n be the *magnitude* of the normal force. Do you think that $n = mg$?

d) List all the components of all the forces, using one of the two formats below.

$$\begin{aligned} F_{gx} &= \cdots \\ F_{gy} &= \cdots \\ n_x &= \cdots \\ n_y &= \cdots \\ &\vdots \end{aligned}$$

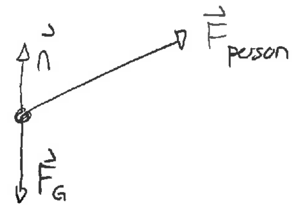
Force	x comp	y comp
$\vec{\mathbf{F}}_g$		
$\vec{\mathbf{n}}$		
$\vdots$		

e) Use Eq. (3) to obtain an equation relating various quantities that appear in this problem. Do the same with Eq. (4). Solve these for the acceleration and the magnitude of the normal force. Is $n = mg$?

f) Suppose that rather than pull up, the person pushed down on the box at the same angle from the left and with the same force. Would the acceleration and normal forces differ from the case where the person pulled up?

g) You may have noticed that the acceleration does not depend on the normal force. This is only true if there is no friction. It turns out that when friction is present, the magnitude of friction force increases as the normal force increases. Knowing this, would pulling up or pushing down give a larger acceleration?

Answers: a)



b) $\sum F_x = ma_x$

$\sum F_y = ma_y = 0$ since object does not move vertically

c) $F_G = mg = 5.0kg \times 9.8 m/s^2$

$= 49N$

For the normal force

$n + \underbrace{F_{person\,y}}_{\text{vertical component of force exerted by person}} = mg \Rightarrow n < mg$

d) $F_{gx} = 0N$

$F_{gy} = -49N$

$n_x = 0N$

$n_y = n$

$F_{px} = 40N \cos 26.6°$

$= 36N$

$F_{py} = 40N \sin 26.6°$

$= 18N$

	x	y
$\vec{F}_G$	0	−49N
$\vec{n}$	0	n
$\vec{F}_p$	36N	18N

e) $\sum F_x = ma_x \Rightarrow 36N = 5.0kg\, a_x \Rightarrow a_x = 7.2m/s^2$

$\sum F_y = 0 \Rightarrow -49N + n + 18N = 0$

$\Rightarrow n - 31N = 0 \Rightarrow \boxed{n = 31N}$ $\boxed{n \neq mg}$

f) What would change is $F_{Py} = -18N$

This would not change $\sum F_x = ma_x \Rightarrow a_x = 7.2 m/s^2$

It would change $\sum F_y = 0$

$\Rightarrow -49N + n - 18N = 0 \Rightarrow n = 67N$

g) Pull up gives smaller $n \Rightarrow$ smaller friction.